Title: Pointers, Lessons Learned, and Rules of Thumb for Successful Vibro-Acoustic Data Acquisition

Abstract: This presentation contains helpful pointers for successful vibroacoustic data acquisition in the following three areas: Instrumentation, Vibration Control and Pyro-shock data acquisition and analysis. A helpful bibliography is provided.

Instrumentation noise reduction:

Use Coaxial cables all the way to the readout. Our lab typically has noise levels around 5 mV rms.

Electrically isolate transducer:

7N-33
4/13 95

-0.002" thick Kapton Tape provides 10^8 Ohm of resistance
-Wrap exposed metal connectors with Kapton
-Ground the transducer only through its signal conditioning equipment
[Photo of test setup of major space craft]

Pyro Shock tests:

-Use the correct transducer size (State of the art is excellent, but don't assume anything!) Good shock accels have a measurement range up to 100,000g and natural frequency over 60kHz. Due to its low sensitivity, question any data with peaks less than 6 dB higher than the background noise level. Always analyze background noise for comparison.

-Good rule of thumb: assume pyro event starts at 100,000 g, then any mechanical joint or 15 cm of homogeneous structural distance results in a 20 dB attenuation. Therefore normal size accels (1000g or less capacity) may be used when there are at least two structural discontinuities between them and the event or they are outside a distance of 30 cm from the event.

-High acoustic and Electromagnetic Pulse levels are frequently associated with pyrotechnic shock events. To combat this, monitor these additional signals by hanging a duplicate transducer near the structurally mounted one.
[Photo of pyrotechnic device]

Vibration control:

State of the art allows:

-Dual (or more) control accelerometers using extremal control strategy
-Monitor cross talk (out-of-axis vibration) and add to control loop if needed. Measure cross-talk on every slip table you use -no exceptions!

Monitor Time Domain!

-all control rooms should have an oscilloscope for monitoring essential channels.
-Spectrum analysis is a batch process; many spurious signals are lost in averaging.

Write A GOOD Test Plan

-Sample
-Key sections include:

- Objective (be honest about why you're doing the test, don't pile too many conflicting objectives on your test personnel!)
- Specification (If you know your objective, then you'd better know how the test will be performed, and done some up-front analysis!)
- Data (The instrumentation, acquisition and analysis you expect to need to get the results you want. Your test lab personnel are invaluable in this highly technical area. Keep your requirements simple!)

Pyro-shock Data Interpretation:

Data Analysis is by Fourier, Energy, and Shock Response Spectrum (widely accepted standard). The SRS mathematically mimics the response of an ideal isolator to the shock event. It only reveals the relative amplitude versus frequency. It does not give you the actual response of a component.

[3 Slides of Time History and SRS]

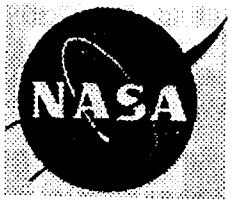
Characteristics of good shock data:
Time History Plot 1:

- -roughly equal positive and negative data
- -no blatant spikes, plateaus or drop outs
- -background noise less than 10% of peaks (throw out data less than twice the amplitude of noise)

Bad Data:
Time History Plot 2:

- -asymmetry
- -zero-shifts
-

Sample frequency at least 10 times the highest analysis frequency.
Low pass (anti-alias) filter at sample frequency.



Pointers, Lessons Learned, and Rules of Thumb for Successful Vibro-Acoustic Data Acquisition

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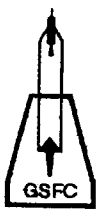
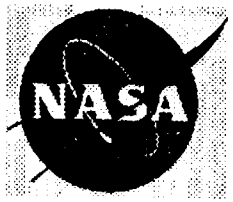


Instrumentation Noise Reduction

- Isolate electrically
  - 10^8 Ohm for 1 layer of .002" Kapton Tape
  - Wrap exposed metal connectors
  - Ground through signal conditioner only
- Coaxial cables all the way to the readout!
- Use correct transducer size/sensitivity
  - Dynamic Range up to 90dB
    - 40 dB 10 years ago
  - State of the art is great, but assume nothing!

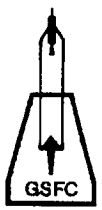
Spurious Signal Reduction -Pyro Shock Tests

- Use shock-type accelerometers for >300g
  - F_n >60 kHz, capacity up to 100,000g
  - Low sensitivity -always analyze the background
  - 20 dB attenuation per 15 cm of homogeneous structure or per discontinuity
  - High EMP, Acoustic levels in vicinity
    - use duplicate, non-mounted transducer
- Acquisition Equipment:
  - Sample at 10x max desired analysis frequency
  - Low pass (anti-alias) filter at sample frequency



Vibration Control

- State of the art allows:
  - Dual (or more) control accelerometers
    - Extremal control strategy
    - Include cross-talk, especially on slip table!
    - Specifications are derived using extreme values - you should run your test the same way!
- Monitor in the Time Domain!
  - oscilloscope in the control room
  - Spectrum analysis is a batch process -damaging spurious signals are lost in the averaging



Vibro-Acoustic Testing

- Write a good test plan with key sections on:
  - **Objective** -be honest about it, don't overdo it!
  - **Specification** -with up-front verification
  - **Data** -instrumentation, acquisition and analysis to yield the results you want
- Consult test lab personnel early
  - Invaluable resource, rarely used
  - Keep requirements simple (see objective)

Pyro-Shock Data

- Shock Response Spectrum -widely accepted
  - Describes shock signal, not transmissibility
- Good Time History: Plot 1
  - Positive and Negative Values are roughly equal
  - No blatant spikes, plateaus, dropouts
  - Low background noise
- Bad Data: Plot 2
  - asymmetry, zero-shifts

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